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A. C. TRUE, Director.

EXPERIMENTS IN SUPPLEMENTAL IRRIGA-
TION WITH SMALL WATER SUPPLIES
AT CHEYENNE, WYO., IN 1909.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., February 21, 1910.

SIR: I have the honor to transmit herewith a report of the work of the season of 1909 at the farm maintained by this Office at Cheyenne, Wyo., under the direction of Samuel Fortier, chief of irrigation investigations of the Office. This farm is conducted for the purpose of determining the possibilities of irrigation with small water supplies in the semiarid region where water for the irrigation of large areas is not available and the larger part of the land must be farmed without irrigation, if farmed at all. Notwithstanding the fact that the season of 1909 had an abnormally large rainfall, the advantages of irrigation are very clearly shown by the crop returns secured at Cheyenne.

The work has been carried on by John H. Gordon, irrigation farmer in charge, and he was assisted in the compilation of the results by Miss A. F. Johnston.

It is recommended that the report be published as a circular of this Office.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

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[Cir. 95]

EXPERIMENTS IN SUPPLEMENTAL IRRIGATION WITH SMALL WATER SUPPLIES AT CHEYENNE, WYO., IN 1909.

The Office of Experiment Stations has maintained since 1905 at Cheyenne and Newcastle, Wyo., and Eads, Colo., experimental farms for the purpose of testing the value of irrigating small areas in connection with the farming of larger areas without irrigation in the semiarid region where water for the irrigation of any large part of the arable land is not available. The results at Cheyenne and Newcastle for the seasons 1905 to 1908 have been published in Circular 92 of this Office. The present report gives the results at the Cheyenne farm in 1909. This is the first season that satisfactory results have been secured. Heretofore the water system was not in good working order, while destructive hailstorms, occurring when crops were maturing, left no measure by which to test the merits of the different systems used.

Although the spring of 1909 was unusually late and the planting of some crops was delayed, the crops were not greatly retarded, and hailstorms did not seriously injure them. A careful record of all operations and yields was kept by the irrigation farmer in charge of the experiment work.

The accompanying map (fig. 1) shows the plats referred to and will assist the reader in following the account of the work.

FULL IRRIGATION V. NO IRRIGATION.

Plats 1, 2, 3, 4, and 5 were irrigated with what was considered sufficient water to produce the best results. Plats 6, 7, 8, 9, and 10 were unirrigated. All the plats from 1 to 10 received the same seeding, tillage, and treatment with the exception of water, and as far as could be judged, the character of the soil in all the plats was the same. The area of each plat is practically 1 acre.

Barley.—Plats 1 and 10 were seeded to Beardless Hull-less barley, and the following shows the results:

Yields of irrigated and unirrigated barley.

Plat.	Treatment.	Amount water applied, in inches.	Amount rainfall, in inches, Jan. 1 to Aug. 5. ^a	Yield, in bushels.	Remarks.
1	Irrigated.....	6.6	11.89	42½	Excellent grade.
10	Unirrigated.....	None.	11.89	16½	

^a Date barley was harvested.

This shows a gain of 26 bushels to the acre in favor of irrigation.

Field peas.—Plats 2 and 9 were seeded to field peas, but when they were fairly above the ground a hailstorm damaged them to such an extent that it was thought advisable to plow the plats and seed to millet as a catch crop, and at the same time prevent the growth of weeds and furnish some forage for the horses. Water to the depth of 4.2 inches was applied to plat 2 at a time when the crop required moisture. Sixty-nine days after seeding there was taken from plat 2

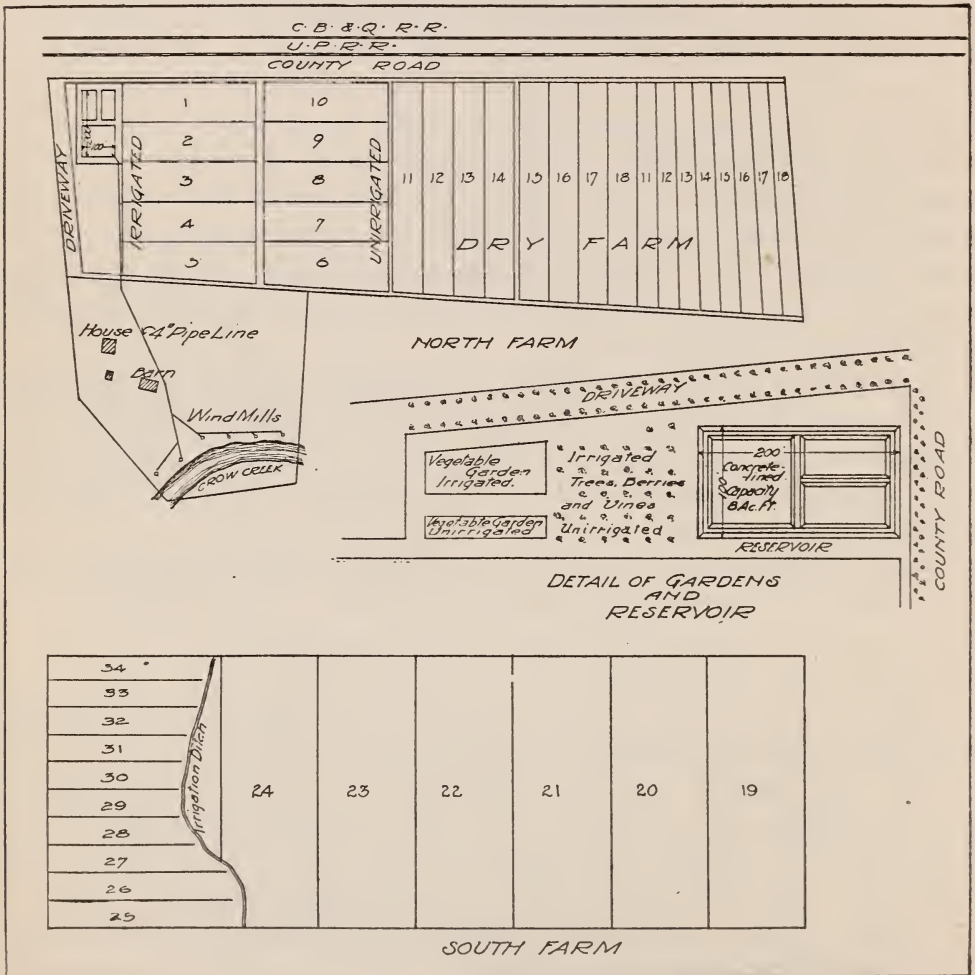


FIG. 1.—Map of Cheyenne farm, showing arrangement of plats.

2,944 pounds of very good millet hay. Plat 9 was harvested at the same time and gave a return of 737 pounds, a gain of 2,207 pounds in favor of the irrigated plat.

Alfalfa.—Plats 3 and 8 were planted to alfalfa in 1908. Two crops were taken from each of these plats during the season of 1909. The yield on plat 3, which received 10.8 inches of water from irrigation, was almost 5,000 pounds. Plat 8 yielded 2,100 pounds, showing a

difference of 2,900 pounds in favor of plat 3. Both plats were damaged by a hailstorm in the early stages of growth. It will be seen from this that a larger amount of water was used than on other crops, but to get the greatest returns from alfalfa water should be applied abundantly, and especially is this true if there is a porous, gravelly subsoil. While it is true that the roots have a natural tendency to penetrate deeply, it is a mistake to depend on this deep rooting alone for moisture, as shown by the large increase in yield on the irrigated plat.

Wheat.—Plats 4 and 7 were planted to Turkey Red winter wheat. Plat 4, to which water was applied 7.38 inches in depth, yielded $38\frac{1}{2}$ bushels of wheat, weighing $59\frac{1}{2}$ pounds to the bushel, showing well-filled grain. From plat 7 no returns were made, all the plants being completely winterkilled. Undoubtedly the cause of such complete failure was the lack of moisture when needed. In 1908 the experience with winter wheat was the same. The irrigated acre yielded 33 bushels of prime wheat, while the unirrigated failed as completely as it did this year. These plats are illustrative of what is called continuous cropping, and the results seem to indicate that this practice is a failure so far as winter wheat is concerned.

Potatoes.—Plats 5 and 6 were planted to potatoes. Plat 5, with an application of 8.57 inches of water, yielded 140 bushels of potatoes, all sizes, and of excellent quality. Plat 6, which was unirrigated, yielded 63 bushels of potatoes, all sizes, and of as good a quality as the irrigated crop, the only difference being in the yield, which was 77 bushels greater on the irrigated plat. The wheat mentioned above as a failure in 1908 was planted on plat 6, consequently the plat was fallowed during the season, and this undoubtedly helped the unirrigated potato crop. Scab made its appearance in both plats, being a little more pronounced in plat 6, but nothing really serious.

SUMMER FALLOWING.

Plats 11 to 18, inclusive, are in the part of the farm devoted to experiments in summer fallowing.

Field peas.—Plat 11 was fallowed during 1908 and seeded to field peas in the spring of 1909, but was so damaged by the hailstorm referred to that it was reseeded to millet, which gave a return of 1,980 pounds on an area of 0.97 acre. Plat 12, having an equal area, was also planted to field peas and replanted to millet, with a yield of 1,920 pounds of good hay. The average for the two plats was 1,950 pounds, or 2,031 pounds per acre.

Comparing this with the yield given on page 4 gives the following: Yield from irrigated land, 2,944 pounds per acre; yield from summer-fallowed land, 2,031 pounds per acre; and yield from land continuously cropped and not irrigated, 737 pounds.

Barley.—Plat 13 was seeded to Beardless Hull-less barley in rows 8 inches apart and produced a yield of 8 bushels from the thresher from an area of 0.8 acre. Plat 14, having the same area, was seeded to the same kind of barley, but in rows 16 inches apart, and was cultivated and gave a yield of 15 bushels, or 10 and 18.8 bushels per acre, respectively. The irrigated plat (p. 3) yielded 42.5 bushels per acre, while the continuously cropped and not irrigated plat yielded 16.5 bushels per acre.

Potatoes.—Plat 15, 0.79 acre, was planted to potatoes in rows 36 inches apart and the seed dropped 17 inches apart in the rows. The yield was 40 bushels of all sizes and very scabby, and hard to sell even at greatly reduced prices on that account. Plat 16 was planted to potatoes in rows 46 inches apart and seed dropped 17 inches apart in the rows. The yield was 59 bushels from the same area as plat 15, but like the product on the first plat the potatoes were very scabby. The seed on part of each plat was treated with corrosive sublimate and formaldehyde, but no difference between potatoes from treated and untreated seed could be noticed. Plat 5, which was irrigated (p. 5), yielded 140 bushels per acre.

Wheat.—Plat 17, having an area of 0.79 acre, was planted to winter wheat in 16-inch rows and cultivated. It was winterkilled to a serious extent and yielded from the thresher but $5\frac{1}{2}$ bushels of very poor quality of wheat, weighing but 55 pounds to the bushel. Plat 18, of the same area, was seeded the same as 17, but in rows 8 inches apart, with no better results, as it was badly winterkilled and yielded but 5 bushels. About one-third of these two plats is so steep and badly situated and have such rocky, gravelly soil as to make them unfit for cultivation, and this accounts, in a great measure, for the small returns from the above plats.

FALL OR SPRING IRRIGATION.

Plats 19, 20, 21, 22, 23, and 24 are 5-acre plats and are situated on what is called the south farm and receive fall or spring watering only.

In the fall of 1908 water was applied to a depth of about 3 feet over the entire six plats. In the spring of 1909 the south half of the plats again received water to the depth of 2 feet. The soil of this portion is very gravelly in character and the moisture was not retained to the same extent as in the northern half.

Alfalfa.—Plat 19 was planted to alfalfa in 1906, two crops being harvested in 1909. The first cutting yielded $7\frac{1}{2}$ tons and the second $2\frac{3}{4}$ tons, making a total of $10\frac{1}{4}$ tons for the season, slightly over 2 tons per acre. The quality of the hay was very good. The crop, in its early stages, was somewhat damaged by hail or a greater yield would

have been produced. It will be noted that there is a great difference in yield between the first and second crops. This is due to the fact that after the first crop is harvested the remainder of the season was unusually dry. But even so, note the decided advantage that fall watering has over dry farming. In comparing the above yield of 4,120 pounds to the acre with plat 8, page 4, where the yield was but 2,100 pounds to the acre, a difference of 2,020 pounds is shown in favor of the plat which was irrigated in the fall and spring.

Barley.—Plat 20 was seeded to Beardless Hull-less barley, from which was harvested 131 bushels of first-class grain which weighed 63 pounds to the bushel from the thresher. According to the standard weight of barley the yield was $34\frac{1}{2}$ bushels to the acre. Plat 10, which was exclusively dry farmed, yielded $16\frac{1}{2}$ bushels to the acre, showing an increase of 18 bushels to the acre in favor of the crop receiving fall watering. These comparisons show the great advantage of fall or spring watering over dry farming, notwithstanding the fact that the precipitation during the year was 3.5 inches above the normal. Large quantities of water which might be used in this way run to waste in the fall and spring months, and this might be used to advantage, as it has been at Cheyenne, and thus supplement dry farming.

Wheat.—Plat 21 was seeded to Defiance wheat and yielded rather poorly, only 8 bushels to the acre, and grain of inferior quality. Two reasons might be assigned for such a small production. As has been stated before, for the past two seasons severe hailstorms seriously damaged the crops, and especially was this true in 1908, when the wheat was at its ripening stage. No doubt the strongest of the grain was lost, making the seed used in 1909 of an inferior grade and not possessed with the vigor of reproduction. Then, again, the Defiance wheat does not withstand drought as well as durum wheat or barley, while hail injures it more. This may, in some measure, account for the light yield. The crops on either side of this plat were very satisfactory.

Oats.—Plat 22 was seeded to oats. Two and one-half acres was seeded with Swedish select oats, which gave a yield of 86 bushels, or 35 bushels to the acre, and the quality was very good. The other $2\frac{1}{2}$ acres was seeded to Kherson oats which yielded 98 bushels, or 39 bushels to the acre. The average yield for the 5 acres was, therefore, 37 bushels to the acre. It has been found that Kherson oats are especially well adapted to this section. Where irrigation can be applied they ripen very early and the most of the growth is completed before the dry season sets in.

Potatoes.—Plat 23 was planted to potatoes and yielded rather poorly from some cause which was not determined. The plat was

planted, cultivated, and kept free from weeds, and the condition or appearance of the plants gave every evidence of producing well. However, the period from June 20 to the early part of September was very dry, and the moisture after that time, although abundant, was not beneficial to the crop. There was a yield of but 42 bushels to the acre, of all sizes, and there were many scabby potatoes among the treated rows as well as the untreated.

Durum wheat.—Plat 24 was planted to durum wheat from which was threshed 84 bushels of first-class grain. This is almost 17 bushels to the acre. From the experience at Cheyenne it seems that the durum wheat will withstand drought much better than any other wheat tried, and it also appears to suffer less from hail than the beardless variety.

DRY FARMING.

Alfalfa.—Plats 25 to 29, inclusive, were planted to alfalfa and exclusively dry farmed. There was but one light cutting, and as the crop over the several plats appeared to be much the same, a portion was measured and weighed and showed a yield of about 1,000 pounds to the acre. On plats 28 and 29 the stand was very poor and the plants had the appearance, to some extent, of being winterkilled. The growth was so small during the latter part of the season that no second cutting was made. Compare this with plat 3, which was irrigated and yielded 5,000 pounds to the acre, a difference of 4,000 pounds to the acre, and with plat 19, which was fall irrigated and where the yield was 4,125 pounds to the acre, a difference in favor of fall irrigation of 3,125 pounds. From the foregoing it would seem that alfalfa can not be recommended as a dry-farm crop for this section. This is further emphasized by the efforts of others in this section to secure a remunerative crop of alfalfa by the dry-farm system.

Potatoes.—Plats 30 and 31 were planted to potatoes. These plats had been fallowed in 1908 and the land was in fine condition as a seed bed in the spring of 1909. From these two plats was harvested 72 bushels of potatoes, or about 61 bushels to the acre, of all sizes and of very good quality. This was the first time potatoes were grown on this land and little scab was found.

Plat 32 was seeded to slender wheat grass in 1907 and has produced two crops. This season's yield was 2,440 pounds to the acre. From the experience of the past two seasons this grass can be recommended highly as a dry-farm crop, provided the same soil tillage be given as on the portion where this experiment was made. Plat 33 was seeded to brome grass at the same time the slender wheat grass was sown and two crops have been harvested with an average yield of 2,400

pounds to the acre, the hay being of very fine quality. The land on which the slender wheat grass and brome grass were grown was fallowed the previous year, 1906, and was kept free from weeds, so that the soil was in excellent tilth. The hay has been fed to work horses and, so far as can be judged, is superior to alfalfa for horse feed.

Plat 34 was planted to durum wheat in the spring of 1909. This plat was fallowed during 1908, and in the spring of 1909 the soil was in a fine tilth. Eleven and one-half bushels were harvested from this plat, which measured 1 acre. Particular attention is called to this plat in comparison with plat 24, which was fall watered and shows a gain of 5 bushels to the acre. When it is considered that plat 24 was cropped in 1908, while plat 34 was fallowed during the same period, it can readily be seen that there is a large advantage in fall or winter irrigation.

GARDEN CROPS WITH AND WITHOUT IRRIGATION.

In connection with the thirty-four plats just reported on, experiments have been carried on in the raising of garden produce with irrigation and without it. The experimental work heré shows that water is absolutely essential to a productive garden; in fact, such products require a great deal more water than field crops. The majority of the plants are tender and do not root deeply, and to promote good growth they must be supplied with ample food, and to make this available abundant moisture is required. The irrigated garden was the admiration of all who visited it, and, considering the elevation of 6,000 feet, the results were marvelous. That portion of the garden which was not irrigated had similar soil and tillage; in fact, all conditions were the same, with the exception of the application of water. The returns were so poor on the unirrigated portion as not to justify the expenditure for labor and seed. It will be seen, therefore, that to have a successful garden in this section irrigation must be practiced.

TREES AND FRUITS.

The growing of shade trees, or windbreaks, and fruit trees has been a part of the experimental work here for several years past. It will be seen from the map that these are located where there is no shelter, and with these unfavorable conditions the growing of trees has not been a success. Three varieties of apple trees have been tried, viz, Wealthy, Winesap, and Jonathan—five trees of each. These were planted in the spring of 1908 and by the following spring only one Winesap, one Jonathan, and four Wealthy trees were alive, the loss being due, undoubtedly, to exposure. From former and present experience, the Wealthy apple is recommended as being able to

withstand adverse conditions better than other varieties, and unless there is a natural or artificial shelter it does not seem advisable to plant any other kind in this region. Of the plum and cherry trees planted in 1908 about half died during the following winter. However, the encouragement from those that did live was enough to try again, and all the dead trees were replaced in the spring of 1909 and made very good growth during the summer. Experiments with shade and forest trees have been much the same, the broad-leaf cottonwood being the only hardy survivor. Lombard and Carolina poplars were planted at the same time, but all have died with the exception of five, which have done fairly well. The poplars have often been tried here, but so far they have not been a success. The broad-leaf cottonwood has made a wonderful growth and the foliage and general appearance have been much admired. The box elder also does well, but until a windbreak has been secured the other varieties do not do well.

Strawberries, blackberries, raspberries, grapes, and currants have alike been unsuccessful in bearing fruit. During the past season the strawberries made a vigorous growth, but were practically unfruitful. This was probably due to the fact that it takes such plants some time to become inured to strange conditions. It will probably take several seasons to test fairly the growing of strawberries. Raspberries and blackberries winterkill very easily, though laid down and covered with earth, which is usually deemed sufficient. Currants seem to withstand the winter very well without any protection, but the growth is very slow. Undoubtedly the cold north winds of this section are the most serious drawback to the growing of these plants.

WINDMILLS.

Reference should be made here to the windmills in operation at the experiment farm. During the past season they have been in excellent working order, not a dollar having been spent on them for repairs, and the maintenance cost confined to the necessary expense for oil. Another report^a deals with these windmills, but it is not out of place here to speak of their usefulness in providing a water supply in connection with extensive dry farming. The small cost of installing and maintaining a reliable windmill places them within reach of the average farmer. A storage reservoir, where water is used for irrigation, is quite essential and can be constructed at a small expense. In many localities puddling alone is all that is necessary to prevent seepage, but it is also very true that some soils will not respond to this treatment, and then it becomes necessary to line the reservoir.

^a U. S. Dept. Agr., Farmers' Bul. 394.

Under some conditions a cement lining is necessary, but even with this additional expense the farmer depending on pumped water will find it a good investment. The water from the reservoir was distributed to the different plats with no waste through 6-inch distributing-pipes, and it has been shown that the economy in water amply justifies the expense of piping. This system has been fully described in a Farmers' Bulletin of this Department.^a

The results of the experiments made during the season of 1909 show fully the great advantage of having a water supply for the irrigation of as large a part as possible of each dry farm, and that the use of storm and flood waters during the fall and winter for the irrigation of lands for which water is not available during the crop-growing season gives valuable results.

^a U. S. Dept. Agr., Farmers' Bul. 263.

